An Accompt of a New Catadioptrical Teleſcope invented by Mr. Newton, *Fellow of the* R. Society, *and Profeſſor of the Mathematiques in the Univerſity of Cambridge.*

THis Excellent Mathematician having given us, in the Tranſactions of *February* laſt, an account of the cauſe, which induced him to think upon *Reflecting* Teleſcopes, inſtead of *Refracting* ones, hath thereupon preſented the Curious World with an *Eſſay* of what may be performed by ſuch Teleſcopes; by which it is found, that Teleſcopical Tubes may be conſiderably ſhortned without prejudice to their magnifying effect.

This new inſtrument is compoſed of two Metallin *ſpeculum's*, the one Concave, (inſtead of an Object-glaſs) the other Plain; and alſo of a ſmall plano-convex Eye-Glaſs.

By *Figure* I. of *Tab.* I. the ſtructure of it may be eaſily imagined; viz. *That* the Tube of this Teleſcope is open at the end which reſpects the object; *that* the other end is cloſe, where the ſaid Concave is laid, and *that* near the open end there is a flat oval *ſpeculum*, made as ſmall as may be, the leſs to obſtruct the entrance of the rays of Light, and inclined towards the upper part of the Tube, where is a little hole furniſh't with the ſaid Eye-glaſs. So that the rays coming from the object, do firſt fall on the Concave placed at the bottome of the Tube; and are thence reflected toward the other end of it, where they meet with the flat ſpeculum, obliquity poſited, by the reflection of which they are directed to the little plano-convex Glaſs, and ſo to the ſpectators Eye, who looking downwards ſees the Object, which the Teleſcope is turned to.

To underſtand this more diſtinctly and fully, the Reader may pleaſe to look upon the ſaid *Figure*, in which

A B is the Concave *ſpeculum*, of which the *radius* or ſemidiameter is $12\frac{2}{3}$ or 13 inches.

C D another metalline *ſpeculum*, whoſe ſurface is flat, and the circumference oval.

G D an Iron wire, holding a ring of braſs, in which the ſpeculum *C D* is fixed.

F, a ſmall Eye-glaſs flat above, and convex below, of the twelfth part of an inch *radius*, if not leſs; foraſmuch as the metal collects the Sun's rays at $6\frac{1}{3}$ inches diſtance, and the Eye-glaſs at leſs than $\frac{1}{6}$ of an inch diſtance from its vertex: Beſides that the Author (as he informs us) knew their dimenſions by the tools to which they were ground, and particularly meaſuring the diameter of the hemi-ſpherical Concave, in which the Eye-glaſs was wrought, found it the *ſixth* part of an inch.

G G G, the fore-part of the Tube faſtn'd to a braſs-ring H I, to keep it immoveable.

P Q K L, the hind-part of the Tube, faſtn'd to another braſs-ring P Q.

O, an Iron hook faſtn'd to the Ring *P Q*, and furniſh't with a ſcrew N, thereby to advance or draw back the hind-part of the Tube, and ſo by that means to put the *ſpecula* in their due diſtance.

M Q G I a crooked Iron ſuſtaining the Tube, and faſtned by the nail R to the Ball and Socket S, whereby the Tube may be turned every way.

The Center of the flat *ſpeculum* C D, muſt be placed in the ſame point of the Tube's Axe, where falls the perpendicular to this Axe, drawn to the ſame from the center of the little Eye-glaſs: which point is here marked at T.

And to give the Reader ſome ſatisfaction to underſtand, in what degree it repreſents things diſtinct, and free from colours, and to know the aperture by which it admits light; he may compare the diſtances of the *focus* E from the *vertex's* of the little Eye-glaſs and the Concave *ſpeculum*, that is, E F, $\frac{1}{6}$ of an inch, and E T V, $6\frac{1}{3}$ inches; and the *ratio* will be found as 1 to 38; whereby it appears, that the Objects will be magnified about 38 times. To which proportion is very conſentaneous, an Obſervation of the Crown on the weather-cock, about 300 feet diſtant. For the ſcheme X fig. 2. repreſents it bigger by $2\frac{1}{2}$ times in diameter, when ſeen through

through this, than through an ordinary Teleſcope of about 2 foot long. And ſo ſuppoſing this ordinary one to magnifie 13 or 14 times, as by the deſcription it ſhould, this new one by the Experiment muſt magnifie near as much as hath been aſſigned.

Thus far as to the ſtructure of this Teleſcope. Concerning the Metalline matter, fit for theſe reflecting *Speculums*, the Inventor hath alſo conſidered the ſame, as may be ſeen by two of his Letters, written to the Publiſher from Cambridge Jan. 18. and 29. 16$\frac{71}{72}$. to this effect, *viz.*

1. That for a fit metalline ſubſtance, he would give this Caution, that whileſt men ſeek for a white, hard and durable metallin compoſition, they reſolve not upon ſuch an one, as is full of ſmall pores, only diſcoverable by a Microſcope. For though ſuch an one may to appearance take a good poliſh, yet the edges of thoſe ſmall pores will wear away faſter in the poliſhing than the other parts of the metal; and ſo, however the Metal ſeem polite, yet it ſhall not reflect with ſuch an accurate regularity as it ought to do. Thus Tin-glaſs mixt with ordinary Bell-metall makes it more white and apt to reflect a greater quantity of light; but withall its fumes, raiſed in the fuſion, like ſo many aerial bubles, fill the metall full of thoſe Microſcopical pores. But white Arſenick both blanches the Metall and leaves it ſolid without any ſuch pores, eſpecially if the fuſion hath not been too violent. What the *Stellate Regulus* of *Mars* (which I have ſometimes uſed) or other ſuch like ſubſtance will do, deſerves particular examination.

To this he adds this further intimation, that *Putty* or other ſuch like powder, with which 'tis poliſhed, by the ſharp angles of its particles fretteth the metall, if it be not very fine, and fills it full of ſuch ſmall holes, as he ſpeaketh of. Wherefore care muſt be taken of that, before judgment be given, whether the metall be throughout the body of it porous or not.

2. He not having tried, as he ſaith, many proportions of the Arſenick and Metall, does not affirm, which is abſolutely beſt, but thinks, there may conveniently be uſed

any quantity of Arſenick equalling in weight between a ſixt and eight part of the Copper, a greater proportion making the Metal brittle.

The way, which he uſed, was this. He firſt melted the Copper alone, then put in the Arſenick, which being melted, he ſtirred them a little together, bewaring in the mean time, not to draw in breath near the pernicious fumes. After this, he put in Tin, and again ſo ſoon as that was melted (which was very ſuddenly) he ſtirred them well together, and immediately powred them off.

He ſaith, he knows not, whether by letting them ſtand longer on the fire after the Tin was melted, a higher degree of fuſion would have made the metall porous; but he thought that way he proceeded to be ſafeſt.

He adds, that in that metall, which he ſent to *London*, there was no Arſenick, but a ſmall proportion of Silver; as he remembers, one ſhilling in three ounces of metall. But he thought withall, that the Silver did as much harm in making the metall ſoft, and ſo leſs fit to be poliſh't, as good in rendring it white and luminous.

At another time he mixed Arſenick one ounce, Copper ſix ounces, and Tin two ounces: And this an Acquaintance of his hath, as he intimates, poliſh't better, than he did the other.

As to the *objection*, that with this kind of Perſpectives, objects are difficultly found, he anſwers in another letter of his to the Publiſher, of Jan. 6. 16$\frac{71}{72}$. that that is the inconvenience of all Tubes that magnifie much; and that after a little uſe the inconvenience will grow leſs, ſeeing that himſelf could readily enough find any day-Objects, by knowing which way they were poſited from other objects that he accidentally ſaw in it; but in the night to find Stars, he acknowledges it to be more troubleſome; which yet may, in his opinion, be eaſily remedied by two ſights affixed to the Iron rod, by which the Tube is ſuſteined; or by an ordinary perſpective glaſs faſtn'd to the ſame frame with the Tube, and directed towards the ſame object, as *Des-Cartes* in his Dioptricks hath deſcribed for remedying the ſame inconvenience of his beſt Teleſcopes.

So far the Inventors Letters touching this Inſtrument: of which having communicated the deſcription to Monſieur *Chriſtian Hugens de Zulichem*, we received from him an Anſwer to this effect, in his Letter of Febr. 13. 1672. ſt.n.

I ſee by the Deſcription, you have ſent me of Mr. *Newtons* admirable Teleſcope, that he hath well conſidered the advantage, which a *Concave ſpeculum* hath above *Convex glaſſes* in collecting the parallel rays, which certainly according to the calculation, I have made thereof, is very great. Hence it is, that he can give a far greater aperture to that *ſpeculum*, than to an Object-glaſs of the ſame diſtance of the *focus*, and conſequently that he can much more magnifie objects this way, than by an ordinary Teleſcope. Beſides, by it he avoids an inconvenience, which is inſeparable from convex Object-Glaſſes, which is the Obliquity of both their ſurfaces, which vitiateth the refraction of the rays that paſs towards the ſides of the glaſs, and does more hurt than men are aware of. Again, by the meer reflection of the metallin *ſpeculum* there are not ſo many rays loſt, as in Glaſſes, which reflect a conſiderable quantity by each of their ſurfaces, and beſides intercept many of them by the obſcurity of their matter.

Mean time, the main buſineſs will be, to find a matter for this *ſpeculum* that will bear ſo good and even a poliſh as Glaſſes, and a way of giving this poliſh without vitiating the ſpherical figure. Hitherto I have found no *Specula*, that had near ſo good a poliſh as Glaſs; and if M. *Newton* hath not already found a way to make it better, than ordinarily I apprehend, his Teleſcopes will not ſo well diſtinguiſh objects, as thoſe with Glaſſes. But 'tis worth while to ſearch for a remedy to this inconvenience, and I deſpair not of finding one. I believe, that M. *Newton* hath not been without conſidering the advantage, which a *Parabolical ſpeculum* would have above a *Spherical* one in this conſtruction; but that he deſpairs, as well as I do, of working other ſurfaces than ſpherical ones with due exactneſs; though elſe it be more eaſie to make a *Parabolical* than *Elliptical* or *Hyperbolical* ones, by reaſon of a certain propriety of the *Parabolick Conoid*, which is, that all the Sections parallel to the Axis make the ſame Parabola.

Thus far M. *Hugenius* his judicious Letter; to the latter part of which, concerning the grinding *Parabolical Conoids*, Mr. *Newton* ſaith, in his Letter to the Publiſher of Feb. 20. 71. that though he with him deſpairs of performing that work by Geometrical rules, yet he doubts not but that the thing may in ſome meaſure be accompliſhed by Mechanical deviſes.

To all which I cannot but ſubjoyn an Extract of a Letter, received very lately, (March 19th) from the Inventor *of this new Teleſcope, from* Cambridge, *viz.*

IN my laſt Letter I gave you occaſion to ſuſpect, that the Inſtrument which I ſent you, is in ſome reſpect or other indiſpoſed, or that the metals are tarniſhed. And by your Letter of *March* 16. I am fully confirmed in that opinion. For, whileſt I had it, it repreſented the Moon in ſome parts of it as diſtinctly, as other Teleſcopes uſually do which magnifie as much as that. Yet I very well know, that that Inſtrument hath its imperfections both in the compoſition of the metall, and in its being badly caſt, as you may perceive by a ſcabrous place near the middle of the metall of it on the poliſhed ſide, and alſo in the figure of that metall near that ſcabrous place. And in all thoſe reſpects that inſtrument is capable of further improvement.

You ſeem to intimate, that the proportion of 38 to 1 holds only for its magnifying Objects at ſmall diſtances. But if for ſuch diſtances, ſuppoſe 500 feet, it magnifie at that rate, by the rules of Opticks it muſt for the greateſt diſtance imaginable magnifie more than $37\frac{3}{4}$ to 1; which is ſo conſiderable a diminiſhing, that it may be even then as 38 to 1.

Here is made another Inſtrument like the former, which does very well. Yeſterday I compared it with a ſix foot Teleſcope, and found it not only to magnifie more, but alſo more diſtinctly. And to day I found, that I could read in one of the *Philoſophical Tranſactions*, placed in the Sun's light, at an hundred foot diſtance, and that at an hundred and twenty foot diſtance I could diſcern ſome of the words. When I made this tryal, its Aperture (defined next the Eye) was equivalent to more than an inch and a third part of the Object-metall. This may be of ſome uſe to thoſe that ſhall endeavour any thing in *Reflexions* ; for hereby they will in ſome meaſure be enabled to judge of the goodneſs of their Inſtruments, &c.

N. B. The Reader may expect in the *next Month* another Letter, which came ſomewhat too late to be here inſerted ; containing a *Table*, calculated by the ſame Mr. *Newton*, about the ſeveral *Apertures* and *Charges* anſwering the ſeveral *Lengths* of theſe Teleſcopes.

EPITOME

Binæ Methodi *Tangentium* Doctoris *Johannis Walliſii* Geom. Prof. Saviliani *Oxoniæ* ; aliàs fuſius & explicatius ab ipſo traditæ, hîc verò ob anguſtiam loci compendifactæ : In quarum Schematiſmis ſi forſan literæ quædam redundaverint, illæ ad ea pertinere cenſendæ ſunt, quæ in ampliori ejuſdem Scripto continentur, hîc vero dictâ de cauſa omittantur.

Habes hic (*Clariſſime vir*) *eorum ſummam* (*ſtrictim traditam*) *quæ fuſiùs ſcripſeram, meas de* Tangentibus Methodos *ſpectantia* ; *duas potiſſimum quibus præſertim utor* ; *alteram in Speciebus*, *alteram in Lineis* ; *utramque generali formâ facilè explicabilem.*

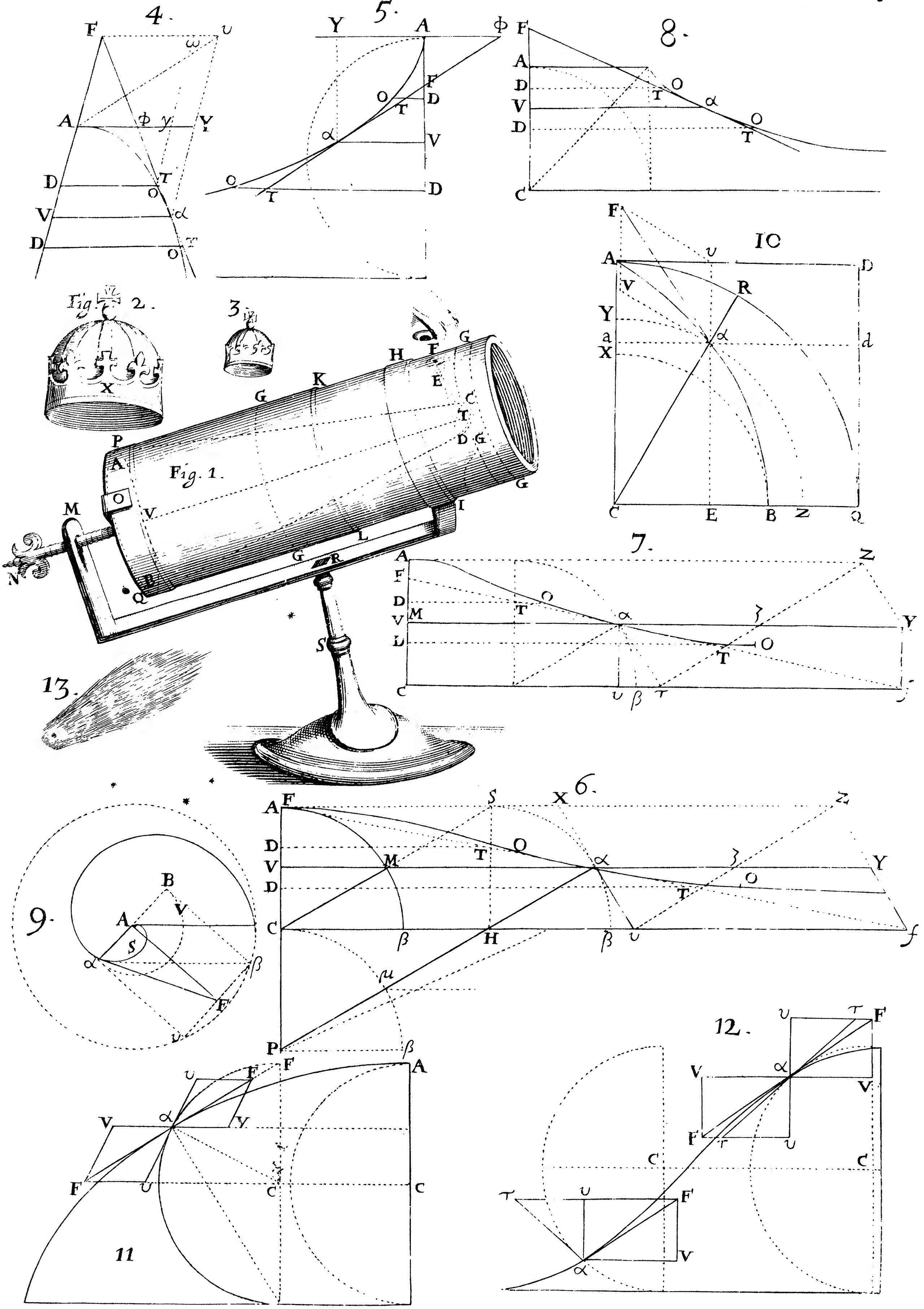
Priorem adhibeo Con.Sect.prop.23,30,36,46,49. & *paſſim alibi. Quæ hæc eſt.*

Expoſitâ Curvâ Aa, (*putà* Parabola, fig.4.) *quam in* a *tangat* aF, *diametro* VDA *occurrens in* F ; *ordinatim applicentur* aV, & DOT *curvæ in* O & *tangenti in* T *occurrens. Ponatur autem* $Va = b$, $VA = v$, $VF = f$, $VD = a$, *adeóque* $DA = v \pm a$, $DF = f \pm a$;

Eſt (*propter ſimilia triangula*) $VF . DF :: Va . DT = \frac{f \pm a}{f} b$.

Item, ſi tangens ſit ultra curvam, $DT \mathrel{\overline{>}} DO$; *ſi citra,* $DT \mathrel{\overline{<}} DO$: *Nempe,* $DT = DO$ *ſi intelligatur* D *in* V ; *ſed, ſi extra* V, DT *vel* DO *major prout tangens eſt ultra citrave curvam.*

Tum,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